

WHAT IS CLAIMED IS:

1. A thin-film magnetic head comprising:  
an antiferromagnetic layer;  
a pinned layer whose direction of magnetization  
5 is fixed by exchange-coupling with said  
antiferromagnetic layer;  
a free layer whose direction of magnetization  
varies according to external magnetic field;  
an intermediate layer disposed between said  
10 pinned layer and said free layer; and  
a pair of electrode layers for supplying a sense  
current to the free layer in a layer thickness  
direction of said free layer,  
one of said electrode layers being connected to  
15 said pinned layer.
2. A thin-film magnetic head according to  
claim 1, wherein said pinned layer comprises a first  
ferromagnetic layer in contact with said  
antiferromagnetic layer, a second ferromagnetic layer  
20 whose direction of magnetization is opposite to that of  
said first ferromagnetic layer, and a nonmagnetic  
spacer layer disposed between said first and second  
ferromagnetic layers;  
said one electrode layer connected to said pinned  
25 layer being in contact with a track-width side face of  
said second ferromagnetic layer but not in contact with

a track-width side face of said first ferromagnetic layer.

5           3.    A thin-film magnetic head according to claim 2, wherein a face of said second ferromagnetic layer opposing said first ferromagnetic layer has an area smaller than that of a face of said first ferromagnetic layer opposing said second ferromagnetic layer.

10           4.    A thin-film magnetic head according to claim 1, wherein said pinned layer, said intermediate layer, and said free layer are disposed between a substrate and said antiferromagnetic layer, and

15           the other electrode layer of said pair of electrode layers that is not connected to the pinned layer is disposed between said free layer and said substrate.

          5.    A thin-film magnetic head according to claim 1, wherein said intermediate layer is formed from an electrically conductive material.

20           6.    A head gimbal assembly having a thin-film magnetic head mounted with a gimbal;

          said thin-film magnetic head comprising:

          an antiferromagnetic layer;

25           a pinned layer whose direction of magnetization is fixed by exchange-coupling with said antiferromagnetic layer;

a free layer whose direction of magnetization varies according to external magnetic field;

an intermediate layer disposed between said pinned layer and said free layer; and

5 a pair of electrode layers for supplying a sense current in a layer thickness direction of said free layer,

one of said electrode layers being connected to said pinned layer.

10 7. A hard disk apparatus comprising a hard disk adapted to write magnetic information therein, and a thin-film magnetic head for reading said magnetic information on said hard disk;

said thin-film magnetic head comprising:

15 an antiferromagnetic layer;

a pinned layer whose direction of magnetization is fixed by exchange-coupling with said antiferromagnetic layer;

20 a free layer whose direction of magnetization varies according to external magnetic field;

an intermediate layer disposed between said pinned layer and said free layer; and

25 a pair of electrode layers for supplying a sense current in a layer thickness direction of said free layer,

one of said electrode layers being connected to

said pinned layer.

8. A method of making a thin-film magnetic head, said method comprising the steps of:

forming an antiferromagnetic layer;

5        forming a pinned layer whose direction of magnetization is fixed by exchange-coupling with said antiferromagnetic layer;

10       forming a free layer whose direction of magnetization varies according to external magnetic field;

forming an intermediate layer disposed between said pinned layer and said free layer; and

15       forming a pair of electrode layers for supplying a sense current to said free layer in a layer thickness direction of said free layer,

one of said electrode layers being formed so as to be connected to said pinned layer.

9. A method of making a thin-film magnetic head according to claim 8, wherein said pinned layer  
20       comprises a first ferromagnetic layer in contact with said antiferromagnetic layer, a second ferromagnetic layer whose direction of magnetization is opposite to that of said first ferromagnetic layer, and a nonmagnetic spacer layer disposed between said first  
25       and second ferromagnetic layers,

said one electrode layer connected to said pinned

layer being formed in contact with a track-width side face of said second ferromagnetic layer but not in contact with a track-width side face of said first ferromagnetic layer.

5           10. A method of making a thin-film magnetic head according to claim 8, wherein said pinned layer comprises a first ferromagnetic layer in contact with said antiferromagnetic layer, a second ferromagnetic layer whose direction of magnetization is opposite to  
10       that of said first ferromagnetic layer, and a nonmagnetic spacer layer disposed between said first and second ferromagnetic layers;

          said method comprising the steps of:

          obtaining said first ferromagnetic layer;

15           forming a magnetic layer to become said second ferromagnetic layer so as to cover said first ferromagnetic layer; and

          patterning said magnetic layer by utilizing a mask so as to obtain said second ferromagnetic layer  
20       having a desirable form;

          wherein a projected area of said mask onto said first ferromagnetic layer is smaller than the area of a face of said first ferromagnetic layer opposing said mask.

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